

Health Consultation

**Evaluation of Contaminants: Public and Private Domestic
Water Supply Wells near Bainbridge Island Landfill
(June 1998 Sampling data)**

Kitsap County, Washington

CERCLIS # WAD980978720

April 1999

**Prepared by
Washington State Department of Health
under cooperative agreement with the
Agency for Toxic Substances and Disease Registry**

FOREWORD

The Washington State Department of Health (DOH) has prepared this health consultation in cooperation with the Agency for Toxic Substances Disease Registry (ATSDR). ATSDR is part of the U.S. Department of Health and Human Services and is the principal federal public health agency responsible for health issues related to hazardous waste. This Health Consultation was prepared in accordance with methodologies and guidelines developed by ATSDR.

The purpose of this Health Consultation is to identify and prevent harmful human health effects resulting from exposure to hazardous substances in the environment. The Health Consultation allows DOH to respond quickly to a request from concerned residents for health information on hazardous substances. It provides advice on specific public health issues. DOH evaluates sampling data collected from a hazardous waste site, determines whether exposures have occurred or could occur, reports any potential harmful effects, and recommends actions to protect public health.

For additional information or questions regarding DOH, ATSDR, or the contents of this Health Consultation, please call the Health Advisor who prepared this document.

Paul Marchant, Public Health Assessor
Washington State Department of Health
Office of Toxic Substances
P.O. Box 47825
Olympia, WA. 98504-7825
(360) 236-3375
1-877-485-7316

BACKGROUND AND STATEMENT OF ISSUES

The Washington State Department of Ecology (Ecology) asked the Washington State Department of Health (DOH) to evaluate potential short-term health threats from vinyl chloride and other contaminants detected in domestic water supply wells in the vicinity of the Bainbridge Island Landfill in Kitsap County, Washington. This health consultation summarizes our evaluation of the public health implications resulting from actual or potential exposure to these contaminants, but does not attempt to identify the source(s) of contamination. Although Ecology is evaluating the Bainbridge Island Landfill (site) as a potential source of contamination, in this health consultation the landfill is cited as a reference point only.

Ecology is currently overseeing a Remedial Investigation and Feasibility Study (RI/FS) for the site pursuant to the Model Toxics Control Act (MTCA). The site is located west of Eagle Harbor on Bainbridge Island and covers 40 acres, of which approximately 7 acres were used for refuse disposal. The landfill stopped accepting waste in 1975. The site comprises the northeast quarter of the northwest quarter of Section 33, Township 25 North, Range 2 East. Approximately 1,200 people live within 1 mile of the site and approximately 56,000 people live within 5 miles of the site (1990 census data).

As part of the Bainbridge Island Landfill RI/FS, Kitsap County is conducting sampling of monitoring wells at the landfill and domestic water supply wells in the vicinity of the landfill to evaluate water quality. This quarter, 16 monitoring and approximately 20 domestic water supply wells were sampled. In the fall of 1998, DOH prepared a health consultation which evaluated and summarized the results of domestic well samples collected from April 1996 through March 1998. DOH concluded that no apparent public health hazard exists from exposure to contaminants detected in any of the wells. This health consultation evaluates and summarizes the results of the June 1998 domestic well sampling data. Subsequent health consultations evaluating quarterly domestic well sampling results through at least the end of 1999 will also be prepared by DOH.

METHODS

How DOH/Office of Toxic Substances (OTS) Evaluates Data

All monitoring well and domestic well sampling data were evaluated without regard to the source of contamination. Only contaminants detected in drinking water wells exceeding a cancer and/or non-cancer health-based screening value were further evaluated in this health consultation. Screening values are media-specific concentrations used to select environmental contaminants for further evaluation. Contaminant concentrations at or below screening values are unlikely to pose a health threat. Contaminant concentrations exceeding screening values do not necessarily pose a health threat, but are further evaluated to determine whether they are at levels observed to cause toxic effects (referred to as toxic effect levels) in human population and/or laboratory animal studies. Exposure assumptions used in this health consultation are listed in Appendix A. Exposure formulas are listed in Appendix B.

Evaluating non-cancer risk:

To evaluate the potential for non-cancer adverse health effects as a result of exposure to contaminated environmental media (i.e, drinking water), a dose was estimated for each contaminant exceeding a health-based screening value. In estimating exposure doses, it was assumed that residents were exposed to the maximum detected chemical concentrations in their drinking water. The estimated dose for an adult and for a child through adulthood for each contaminant were then compared to ATSDR's minimal risk levels (MRLs) or EPA's oral reference dose (RfDs). MRLs and RfDs are estimates of daily exposure of a human to a chemical that is likely to be without an appreciable non-cancer risk over a specified duration of exposure. They are derived from toxic effect levels obtained from human and laboratory animal studies. These toxic effect levels are expressed as either the lowest adverse effect level (LOAEL) or the no-observed adverse effect level (NOAEL). In human or animal studies, the LOAEL is the lowest dose at which an adverse effect is seen, while the NOAEL is the highest dose that did not result in any adverse health effects.

Because of the uncertainty associated with these data, the toxic effect levels are divided by safety factors (usually 100 or 1,000) to provide the more protective MRL or RfD. If a dose exceeds the MRL or RfD, the *potential* exists for adverse health effects. Thus, a dose only slightly exceeding the MRL or RfD would fall well below the toxic effect level. The higher the estimated dose is above the MRL or RfD, the closer it will be to the toxic effect level.

Evaluating cancer risk:

For screening of chemicals which are known or expected to cause cancer, it is assumed that no "safe" level exists, and EPA cancer slope factors are used to calculate an "estimated" increased cancer risk. An exposure which results in an estimated increased cancer risk of one additional cancer in a population of one million people exposed over a 70 year lifetime, is considered an acceptable risk, and is used as the screening value. In a population of one million men in the U.S., 333,000 are expected to develop cancer from all causes in their lifetime (through 79 years of age). For U.S. woman, the figure is 200,000 (American Cancer Society Facts and Figures, 1998). The additional estimated cancer risk means that if those one million men are exposed for 70 years to this level of the chemical, 333,001 would be expected to develop cancer. For those one million woman exposed, 200,001 would be expected to develop cancer.

How DOH Office of Toxic Substances evaluation methods differ from DOH Office of Drinking Water

Kitsap County Department of Public Works and the Bremerton/Kitsap County Health District have raised questions concerning the difference between the DOH Office of Toxic Substances (OTS) and DOH Office of Drinking Water (DW) in evaluating contaminants in drinking water supplies. Within the Environmental Health Division of DOH, both the DW office and OTS have roles in evaluating contaminants in domestic drinking water supplies. To assist the reader in understanding the differences between our respective roles and the criteria each of our offices

use to evaluate exposure to contaminants (i.e., MCLs vs. ATSDR criteria), it is necessary to explain our respective mandates and responsibilities.

The DOH/DW Office regulates public water systems. In Kitsap County, responsibility for public systems serving 25 or fewer connections is delegated to the Bremerton/Kitsap County Health District. Federal and State drinking water standards, called *maximum contaminant levels (MCLs)* are used by the DOH/DW Office and Bremerton/Kitsap County Health District in regulating these systems, and are *legally enforceable standards*. Although generally protective of public health, other non health-based considerations were made when developing MCLs, such as the ability of public water systems to detect and remove contaminants using suitable treatment technologies, implementation costs, and analytical limitations. In setting the MCL for vinyl chloride, for example, the Environmental Protection Agency has adopted a value which corresponds to the higher end of their acceptable risk range (one additional cancer per 10,000 people exposed, averaged over a lifetime). Also, the MCL does not consider routes of exposure other than ingestion (i.e., inhalation and dermal contact). For these reasons, DOH/OTS does not rely on MCL values alone as an indicator of potential health risk. As a result, DOH/OTS can, and sometimes does, *recommend* actions at levels below that which the DOH/DW Office may require of public water systems.

DOH/OTS's role is to provide technical assistance to agencies, groups, or individuals on actual or potential health risks from exposure to hazardous substances in the environment, such as contaminants in drinking water supplies. We evaluate data and draw conclusions about potential health risks based on *site-specific exposure scenarios* and by utilizing current chemical toxicity information and standard risk assessment methodologies to estimate exposures. In doing so, DOH/OTS goes a step further (beyond simply comparing the contaminant concentration to the numerical MCL value) in assessing potential health risk. Our conclusions can result in recommendations for actions to protect public health. However, our recommendations are just that, and are *not legally enforceable*.

DATA SUMMARY

A total of 22 domestic wells were sampled by Kitsap County during the June sampling round. Four of the domestic wells are Group B wells (a public water system that serves more than one connection but less than 25 people or 15 connections) and one is a Group A well (a public water system with 15 or more service connections or an average of 25 or more people per day for 60 or more days within a calendar year). The Group A well serves 1 residence and a school/day care facility. The remaining domestic wells are private wells serving individual residences.

Domestic supply wells were initially analyzed for many parameters, including volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), polynuclear aromatic hydrocarbons (PNA), inorganics (total and dissolved), and conventional parameters (total organic carbon, temperature, nitrate, pH, alkalinity, chloride, total dissolved solids, dissolved oxygen, sulfate, etc.). June 1998 domestic well sample analysis included VOCs and conventional parameters in all 22 wells, and inorganics, pesticides, herbicides, SVOCs,

polynuclear aromatics (PNAs) and petroleum hydrocarbons (PHCs - gas, oil, and diesel-range hydrocarbons) in 4 of the wells.

Five VOCs were detected at low levels during the June sampling round, although vinyl chloride was the only one which slightly exceeded an ATSDR screening value. None of the inorganic detections exceeded ATSDR screening values. Contaminants detected below ATSDR screening values are unlikely to pose a public health threat and will not be discussed further in the health consultation. Table 1 lists the domestic wells with the single highest chemical detections, each chemical's health-based screening value, the well types, well identification code (ID), and approximate number of residences served by the well.

TABLE 1
CONTAMINANTS IN DOMESTIC WELLS
(JUNE 1998 VALIDATED DATA)

Chemical/Analyte	Highest Concentration (µg/l)	Carcinogenic Screening Value (µg/l)	Non-carcinogenic Screening Value (µg/l)	Well ID	Well Type	Number of Residences Served
1,1-Dichloroethane	0.2	NA	800 (MTCA method B)	BOW37	Group B	6
1,1,1-Trichloroethane	0.2 (J)	NA	200 (MCL/LTHA)	BOW52	Private	1
Acetone	1.1 (M)	NA	1,000 (child RMEG)	BOW04	Private	2
Dichlorodifluoromethane	2.2	NA	2,000 (child RMEG)	BOW37	Group B	6
<i>Vinyl chloride</i>	<i>0.39</i>	NA	<i>0.2 (child chronic EMEG)</i>	BOW37	Group B	6
<i>Total coliform</i>	<i>200 CFUs/100 ml</i>	NA	1 (MCL)	BOW35	Private	1

µg/l = micrograms of chemical per liter of water (equals one part per billion).

RMEG = ATSDR's Reference Dose Media Evaluation Guide

MTCA B = WA Model Toxics Control Act Method B groundwater cleanup level

NA = Not available

MCL = Federal and state drinking water standard

LTHA = EPA's Lifetime Health Advisory for Drinking Water

EMEG = ATSDR's Environmental Media Evaluation Guide

CFU = Colony forming unit

J = estimated value between the calculated detection limit and reporting limit

M = estimated value of analyte found and confirmed by analyst but with low spectral match

bolded/italicized compounds = compounds exceeding an ATSDR screening value which required further evaluation

Discussion

After evaluating all of the June sampling data, *DOH concluded that no health threat exists for people exposed for 1-5 years to any of the contaminants detected in the domestic wells. Although a very low chronic (long-term) health risk exists from exposure to the*

maximum concentration of vinyl chloride in well BOW37, there is no apparent public health hazard. ATSDR uses the “no apparent public health hazard” category for sites where human exposure to contaminated media is occurring or has occurred in the past, but the exposure is below a level of health hazard. Inhalation and ingestion are the major routes of exposure for this site. DOH evaluated both of these routes.

The Kitsap County Department of Public Works plans to continue sampling domestic supply wells quarterly through at least the end of 1999. DOH is working closely with the Bremerton/Kitsap County Health District and Ecology, and will continue to evaluate quarterly sampling results to determine future recommendations.

Contaminants exceeding a screening value which were further evaluated:

The following contaminants detected in individual domestic wells exceeded an ATSDR health-based screening value or MCL and were thus further evaluated in the health consultation:

- Vinyl chloride
- Coliform

Vinyl Chloride

The maximum vinyl chloride concentration during the June 1998 sampling event was 0.39 µg/l from well BOW37, located approximately 800 feet northeast of the landfill. The maximum concentration of vinyl chloride detected in any domestic well since sampling began in 1996 was 0.77 µg/l from this same well in October 1996. Concentrations in this well slowly decreased from October 1996 through September 1997, then leveled off through the present. Vinyl chloride has been detected at low levels in 12 of the 25 domestic wells sampled (48%) since 1996.

Vinyl chloride is a colorless gas at normal temperatures. All vinyl chloride is manufactured or results from the breakdown of manufactured substances, such as trichloroethylene, trichloroethane, and tetrachloroethylene (commonly used cleaning and degreasing compounds). Most of the vinyl chloride produced in the United States is used to make polyvinyl chloride (PVC). PVC is used to make a variety of plastic products including pipes, wire, cable coatings and packaging materials. Other uses include furniture and automobile upholstery, wall coverings, housewares, and automotive parts.

Short-term health effects may include damage to the nervous system. Breathing high levels (>1,000 ppm) of vinyl chloride can cause dizziness and sleepiness. Animal studies have demonstrated that exposure to extremely high levels of vinyl chloride can damage the liver, lungs, and kidneys. Other animal studies suggest that long-term inhalation exposure to vinyl chloride may damage the sperm and testes and cause high blood pressure during pregnancy. Studies using pregnant animals show that breathing high levels (2-500 ppm) of vinyl chloride may harm their unborn offspring. Animal studies also show that vinyl chloride may cause increased numbers of miscarriages early in pregnancy. It may also cause decreased weight and

delayed skeletal development in fetuses. The effects of drinking high levels of vinyl chloride are unknown. The MRL was derived from a LOAEL value of 0.018 mg/kg/day for an increased incidence of areas of cellular alteration in the livers of rats.

Results from several studies suggest that breathing air or drinking water containing low levels of vinyl chloride may increase the risk of developing cancer. Hepatic angiosarcomas in Sprague-Dawley rats were observed at doses approximately 5,000 times greater than doses estimated for persons chronically exposed to the June 1998 vinyl chloride concentration in well BOW37. Studies of workers who have been exposed to vinyl chloride over many years also indicate increased incidences of angiosarcoma of the liver. Brain, lung, and some blood cancers may also be attributed to chronic inhalation exposure to vinyl chloride. Studies of long-term exposure in rats indicate that increases in liver and mammary gland cancer may occur at very low levels of exposure in the air (5-250 ppm). The Department of Health and Human Services, International Agency for Research on Cancer, and EPA have determined that vinyl chloride is a human carcinogen.

EPA is currently reassessing vinyl chloride's carcinogenicity, and has thus removed the oral slope factor. However, for this health consultation, the former oral slope factor of 1.9 was used to estimate the excess cancer risk from exposure to this compound. The estimated increased cancer risk, assuming chronic exposure to the maximum concentration (0.39 µg/l) of vinyl chloride in drinking water from well BOW37, is approximately 3 additional cancers per 100,000 persons exposed from childhood through adulthood, and approximately 2 additional cancers per 100,000 persons exposed as an adult (very low increased cancer risk).¹ The estimated doses for both the child through adult and adult exposure scenarios are at the chronic oral MRL, but below the less serious LOAEL for oral exposure, indicating that exposure to the maximum detected concentration of vinyl chloride is not expected to result in adverse non-cancer health effects.

Coliform

Total coliform bacteria were detected above the Safe Drinking Water Act MCL in well BOW35 (a private well) during the June sampling event. The coliforms are a broad class of bacteria which live in the digestive tracts of humans and many animals. There are a variety of bacteria, parasites, and viruses which can cause immediate (though usually not serious) health problems when humans ingest them in drinking water. Testing water for each of these pathogens would be difficult and expensive. Instead, water quality and public health specialists measure coliform levels. The presence of any coliforms in drinking water suggests that there may be disease-causing agents in the water.

The presence of coliform bacteria in tap water suggests that the treatment system is not working

¹ A review of Health District records indicate that BOW37 was initially drilled as a private well in 1976. County Assessor records indicate that homes were built and connected to the water supply in 1983, 1986, and the mid 1990s. As a result, estimated exposures, and thus risk, would be even less than this since a 30-year exposure duration was assumed for this health consultation.

properly or that there is a problem in the pipes. Among the health problems that contamination can cause are diarrhea, cramps, nausea and vomiting. Together these symptoms comprise a general category known as gastroenteritis. Gastroenteritis is not usually serious for a healthy person, but it can lead to more serious problems for people with weakened immune systems, such as the very young, elderly, or immuno-compromised.

The Total Coliform Rule (published June 29, 1989/effective December 31, 1990) set both health goals (MCLGs) and legal limits (MCLs) for total coliform levels in drinking water. The rule also details the type and frequency of testing that public water systems must conduct. In the rule, EPA set the health goal for total coliforms at zero. Since there have been waterborne disease outbreaks in which researchers have found very low levels of coliforms, any level indicates some health risk.

When coliforms are found, it may indicate that the system's treatment process is not performing properly. To avoid or eliminate microbial contamination, systems may need to take a number of actions, including repairing the disinfection/filtration equipment, flushing or upgrading the distribution system, and enacting source water protection programs to prevent contamination. Only one well was found to exceed the coliform standard.

Child Health and Developmental Effects

Vinyl chloride:

No human or animal studies were located regarding developmental or reproductive effects following oral exposure to vinyl chloride. However, some data suggests that fetuses, infants, and young children may be particularly susceptible to the toxic effects of vinyl chloride. Vinyl chloride can cross the placenta and enter the blood of fetuses. Developmental effects have been observed as a result of parental exposures to vinyl chloride in the air. A statistically significant increase in birth defects was observed in three cities in which facilities using vinyl chloride were located when compared to statewide and county wide averages. The greatest increases were malformations of the central nervous system, upper digestive tract, genital organs, and in the incidence of club foot.

Results of animal inhalation studies indicate that vinyl chloride produces developmental effects at concentrations that are also toxic to maternal animals. Maternal toxicity was evidenced by decreased food consumption, decreased body weight, and increased mortality. Delayed ossification was noted in fetuses at 500 ppm. Vinyl chloride exposed rats throughout gestation showed an increased incidence of hemorrhages, increased edema, decreased hemoglobin and leukocytes and decreased organ weights. However, doses at which developmental effects were observed were several orders of magnitude higher than estimated doses resulting from exposure to vinyl chloride from well BOW37.

Conclusions

No health threat exists for people exposed for 1-5 years to concentrations of contaminants detected in any of the domestic wells sampled to date.

Long-term ingestion/inhalation exposure (DOH assumed 30 years) to the maximum detected vinyl chloride concentration (0.39 µg/l) poses a very low increased cancer risk. However, the risk would increase if the concentration increased.

Based on DOH's evaluation of all of the domestic well data provided to date, no apparent public health hazard exists as a result of exposure to contaminants detected in any of the wells.

Recommendations

1. Continue quarterly monitoring of domestic wells. Provide DOH with the results of the quarterly monitoring for review and evaluation.

Actions

➤ DOH completed health consultations evaluating quarterly domestic well sampling results from April 1996 - March 1998. Quarterly monitoring continues, and Kitsap County Public Works will submit the sampling results to DOH for review and evaluation. Health consultations will be prepared for each sampling round.

2. Continue to monitor well BOW37 for VOCs to observe that vinyl chloride concentrations do not increase in subsequent quarters. If vinyl chloride (or other VOCs) show increasing trends or reach federal Safe Drinking Water Act Maximum Contaminant Levels (MCLs), exposures should be reduced or eliminated. DOH will continue to review and evaluate quarterly well monitoring results to determine future recommendations; or reduce or eliminate exposure to contaminants from this well (options could include treatment or an alternate water source).*

Actions

➤ Well BOW37 has been sampled and evaluated, and the owner notified of the results. This well has consistently shown the highest vinyl chloride detections and continues to be monitored quarterly for VOCs and conventional parameters.

3. Kitsap County should advise the owner of well BOW35 on steps to address the coliform detection, including follow-up testing and/or recommendations for treatment.

Actions

➤ The Bremerton/Kitsap County Health District has notified the well owner of the coliform detection, and provided recommendations for follow-up.

4. Ecology's March 1995 and March 1998 letters recommending that the Bremerton/Kitsap County Health District limit its well site approval in the areas identified in the vicinity of the landfill should be followed.

Actions

➤ Bremerton/Kitsap County Health District is adhering to Ecology's recommendations.

5. Should future public health intervention become necessary, DOH will work with the appropriate agencies to address the possible long-term need for an alternate water source or treatment for wells determined to be at risk.

Actions

➤ Thus far, contaminant concentrations and trends have not warranted alternate water supplies. However, DOH continues to evaluate monitoring results and will work with the appropriate agencies to address treatment options or alternate water supplies should they become necessary.

* Our recommendation to reduce or eliminate exposure to contaminants detected in this well is intended to prevent *future* exposures to potentially higher VOC concentrations from occurring in the event monitoring is discontinued. As previously indicated, since 1996, when this well was first tested, contaminant levels have dropped in half and monitoring will continue through at least the end of 1998. DOH will continue to assess contaminant trends in this, and other domestic wells being sampled, to determine future recommendations.

DOH site actions to date:

- ▶ DOH prepared a draft health consultation evaluating contamination in offsite public and private domestic wells near the Bainbridge Island Landfill.

- ▶ July 1998: DOH prepared and mailed a fact sheet summarizing the health consultation findings to approximately 800 area residents .
- ▶ July 1998: DOH worked closely with the Bremerton/Kitsap County Health District to notify all residents whose wells were evaluated for the health consultation. The health consultation findings were provided to the residents, both verbally, and in writing. Kitsap County also offered to provide health education to the residents, but they indicated that it was not needed.
- ▶ July 1998: The health assessor summarized DOH activities at the Bainbridge Island Landfill site to be included in the Governor’s weekly “Alert” report.
- ▶ August 1998: DOH worked closely with the agencies involved with this site to provide information to the Bainbridge Island Review newspaper for an in-depth article.
- ▶ September 1998: Per Ecology’s request, DOH submitted a letter to Ecology’s site manager summarizing our recommendations for offsite domestic wells which could be eliminated from sampling, and those which we feel should not be eliminated from sampling.
- ▶ November 1998: DOH will finalize and mail copies of the health consultation evaluating offsite domestic well sampling data (April 1996 to March 1998). Approximately 75 copies will be mailed to area residents and agencies involved in the site investigation.
- ▶ December 1998: DOH will finalize and distribute copies of this health consultation, which evaluated June 1998 domestic well sampling results, to the same number of residents.
- ▶ Ongoing: DOH will continue to maintain frequent communication with Ecology and Kitsap County regarding site activities and quarterly well sampling results, and will prepare health consultations on subsequent domestic well sampling data sets.

Appendix A - Exposure assumptions:

For this health consultation, it was assumed that residents were exposed 350 days per year, for thirty years to the contaminant concentrations highlighted in Table 1. This exposure duration was intended to account for potential past and future exposures, as well as current exposures. Both adult and child through adult exposure scenarios were evaluated. Adults were assumed to

consume 2 liters of water per day, and children were assumed to consume 1 liter of water per day until 5 years of age and 2 liters of water per day for the remaining 25 years. Children were assumed to be exposed for 5 years at a 16 kilogram (kg) body weight, for 10 years at a 40 kg body weight, and for 15 years at a 70 kg body weight. Children and adults were assumed to be exposed to VOCs through ingestion (drinking) and non-ingestion (inhalation and dermal contact) routes. Non-ingestion exposures are assumed to occur during household activities such as cooking, bathing, and dishwashing.

Appendix B-Exposure formulas:

It is assumed that non-ingestion (inhalation and dermal) exposures are equal to exposures through ingestion.

$$\text{Exposure dose} = [(C \times IR \times EF \times ED)/BW \times AT)] \times 2$$

$$\text{Additional lifetime cancer risk} = \text{Estimated exposure dose} \times \text{CSF}$$

where:

C = concentration of contaminant ($\mu\text{g/l}$)

IR = Ingestion rate (liters of water/day)

EF = Exposure frequency (days/year)

ED = exposure duration (total # of years in exposure period)

BW = body weight

AT = averaging time (70 years \times 365 days/year)

CSF = Cancer slope factor (Estimates the excess upperbound lifetime probability of an individual developing cancer from an exposure)

References

1. Bainbridge Island Landfill Validated Data Set 9, CH2M Hill, October 5, 1998.
2. Draft Remedial Investigation Report, Volumes 1 and 2, Bainbridge Island Landfill, August 25, 1997. Kitsap County Department of Public Works, Solid Waste Division.
3. Draft Remedial Investigation Report, Supplement No. 1, Bainbridge Island Landfill, May 4, 1998. Kitsap County Department of Public Works, Solid Waste Division.
4. Bainbridge Island Landfill site, Public Groundwater Supplies, Kitsap County, WA., EPA Geographic Information Query System (Version 97.1.8), March 24, 1998.
5. Integrated Risk Information System (IRIS), October 1998.
6. ATSDR Health Consultation Procedures, Agency for Toxic Substances and Disease Registry, May 1995.
7. Toxicological Profile for Vinyl Chloride, U.S. Department of Health and Human Services, Public Health Service, ATSDR, September 1997.
8. Coliform Monitoring, Washington State Department of Health, Division of Drinking Water, February 1992.
9. Conversations with Barbara Trejo, Washington State Department of Ecology, 1998.
10. American Cancer Society: Facts and Figures: 1998 Cancer statistics.
11. Drinking Water Standards for Regulated Contaminants: Total Coliform Rule. U.S. EPA, Office of Groundwater and Drinking Water.

DEFINITIONS

EMEG: ATSDR's Environmental Media Evaluation Guide. A concentration in air, soil, or water (or other environmental media), which is derived from ATSDR's MRL, and below which adverse non-cancer health effects are not expected to occur. Separate EMEGs can be derived to account for acute, intermediate, or chronic exposure durations.

RMEG: ATSDR's Reference Dose Media Evaluation Guide. A concentration in air, soil, or water (or other environmental media), which is derived from EPA's RfD, and below which adverse non-cancer health effects are not expected to occur. RMEGs account only for chronic exposure.

MRL: ATSDR's Minimal Risk Level. An estimate of daily human exposure to a dose of chemical that is likely to be without an appreciable risk of adverse noncancerous health effects over a specified duration of exposure. MRLs are derived when reliable and sufficient data exist to identify the target organ(s) of effect or the most sensitive health effect(s) for a specific duration via a given route of exposure. MRLs can be derived for acute, intermediate, and chronic duration exposures by the inhalation and oral routes.

CREG: ATSDR's Cancer Risk Evaluation Guide. A concentration in air, water, or soil (or other environmental media), which is derived from EPA's cancer slope factor and carcinogenic risk of $10E-6$ for oral exposure. It is the concentration that would be expected to cause no more than one excess cancer in a million persons exposed over a lifetime.

CHRONIC RfD: An estimate (with uncertainty spanning perhaps an order of magnitude) of the daily exposure level of the human population, including sensitive subpopulations, to a potential hazard that is likely to be without an appreciable risk of deleterious effects (non-cancer) during a lifetime. It was developed to be protective for long-term exposure to a compound (7 years or longer).

CANCER SLOPE FACTOR: A plausible upperbound estimate of the probability of a response per unit intake of a chemical over a lifetime. The slope factor is used to estimate an upperbound probability of an individual developing cancer as a result of a lifetime of exposure to a particular level of a potential carcinogen.

LOAEL: Lowest Observed Adverse Effect Level. LOAEL's have been classified into "less serious" or "serious" effects. In dose-response experiments, the lowest exposure level at which there are statistically or biologically significant increases in the frequency or severity of adverse effects between the exposed population and its appropriate control.

NOAEL: No Observed Adverse Effect Level. The dose of a chemical at which there were no statistically or biologically significant increases in frequency or severity of adverse effects seen between the exposed population and its appropriate control. Effects may be observed at this dose, but were judged not to be "adverse".

MCL: Federal Maximum Contaminant Level. A drinking water regulation established by the Safe

Drinking Water Act. It is the maximum permissible concentration of a contaminant in water that is delivered to the free-flowing outlet of the ultimate user of a public water system. MCLs are enforceable standards.

CARCINOGEN: Any substance that can cause or contribute to the production of cancer.

CONTAMINANT: Any substance or material that enters a system (the environment, human body, food, etc.) where it is not normally found.

MONITORING WELLS: Wells developed to collect groundwater samples for the purpose of physical, chemical, or biological analysis to determine the amounts, types, and distribution of contaminants.

PLUME: An area of chemicals in a given media, such as groundwater.

REMEDIAL INVESTIGATION: A study designed to collect the data necessary to determine the nature and extent of contamination at a site.

COMPARISON VALUE: A concentration used to select contaminants of concern at hazardous waste sites that are further evaluated in the health assessment process. The terms comparison value and screening level are often used synonymously.

CLHA: Child Long-Term Health Advisory

MTCA: Model Toxics Control Act. Washington States hazardous waste cleanup law.

MCLG: Maximum Contaminant Level Goal.

FIGURES

Figure 1: Bainbridge Island Landfill Site Location Map

Figure 2: Bainbridge Island Landfill Regional Topography and Surface Water Drainages

Figure 3: Bainbridge Island Landfill Offsite Domestic Wells

Figure 4: Bainbridge Island Landfill Municipal Wells

Figure 5: Bainbridge Island Landfill Municipal Wells